Available online at www.sciencedirect.com
SCIENCE DIRECT®
PERGAMON
Marine Pollution Bulletin 46 (2003) 935–940
MARINE POLLUTION BULLETIN
www.elsevier.com/locate/marpolbul

Focus

Economic and environmental impacts on ports and harbors from the convention to ban harmful marine anti-fouling systems

Michael A. Champ *

Advanced Technology Research Project (ATRP) Corporation, P.O. Box 2439, 7000 Vagabond Drive Falls Church, VA 22042, USA

Abstract

The recent Diplomatic Conference held (1–5 October 2001) by the International Maritime Organization (IMO) in London adopted the Draft Convention prepared by The Marine Environmental Protection Committee (MEPC) of IMO for the "Control of Harmful Anti-fouling Systems for Ships." The convention has been developed to immediately ban the use of Tributyltin (TBT) globally in anti-fouling paints to "protect the marine environment". The ban on TBT has come about because TBT has detrimental effects on non-target marine organisms. In November 1999, IMO agreed that a treaty be developed by the MEPC to ensure a ban on the application of TBT based anti-fouling paints by 1 January 2003, and a ban on the use of TBT by 1 January 2008.

At the meetings, serious concern was expressed by some experts for the need to identify in the treaty the necessary regulatory language for: (1) the "safe" removal, treatment, and disposal of marine anti-foulants deemed "harmful" by the treaty and (2) who is liable for the future dredging and disposal of TBT-contaminated port and harbor sediments—to *also* "protect the marine environment".

The requirement for "safe" removal and disposal was incorporated at MEPC 46 as Article 5 in the treaty, without it shipyards complying with existing national and local discharge regulations (most have none for discharge of TBT) could inadvertently release more TBT to ports and harbors in the five-year compliance period than has been leached from ships (hulls) in the past 40 years to the same waters. Virginia is the only State in the US that regulates the discharge to below 50 ng/l (50 parts per trillion). However, the liability for the future dredging and disposal costs of TBT-contaminated port and harbor sediments has not been addressed.

1. The TBT treaty

A new International Maritime Organization (IMO) Convention to "Control the use of "Harmful Anti-fouling Systems on Ships" was adopted on 5 October 2001, following a five-day Diplomatic Conference held at IMO Headquarters in London (Champ, 2001a). The convention will prohibit the use of harmful organotins in anti-fouling paints used on ships and establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems (www.imo.org).

Provisions, specific requirements and the adopted resolutions of the adopted convention are presented in boxes.

2. Current shipyard practices—Future costs

Two international conferences (Seattle—Oceans '99 and Miami—Oceanology International 2001) have been held in the US to bring together researchers from across the world to share their experiences and findings related to prevention of pollution from ships, shipyards and drydocks and treatment processes to remove biocides from spent paint removed from ships and to look at new alternative marine anti-fouling coatings, with published proceedings (Champ et al., 1999; Champ, 2001b).

Current shipyard practices use freshwater and hydro blasting technologies (high pressure pumps) to washdown (to remove salt, slime, and biofouling) and paint from vessels. This produces washdown wastewater, which is discharged into waterways, contaminating port and harbor bottom sediments. If TBT is banned by international treaty as proposed, the future cost of removal of dredged material from harbors and waterways could increase significantly (estimates are up to 5–15

* Tel.: +1-703-237-0505; fax: +1-703-241-1278.
E-mail address: machamp@aol.com (M.A. Champ).
URL: http://www.atrp.com

0025-326X/$ - see front matter © 2003 Published by Elsevier Ltd.
doi:10.1016/S0025-326X(03)00106-1

Treaty specific requirements:

Under the terms of the new convention, parties to the convention are required to prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag, as well as ships not entitled to fly their flag but which operate under their authority and all ships that enter a port, shipyard or offshore terminal of a Party.

Ships of above 400 gross tonnage and above engaged in international voyages (excluding fixed or floating platforms, FSUs and FPSOs) will be required to undergo an initial survey before the ship is put into service or before the International Anti-fouling System Certificate is issued for the first time; and a survey when the anti-fouling systems are changed or replaced.

Ships of 24 m or more in length but less than 400 gross tonnage engaged in international voyages (excluding fixed or floating platforms, FSUs and FPSOs) will have to carry a Declaration on Anti-fouling Systems signed by the owner or authorized agent. The Declaration will have to be accompanied by appropriate documentation such as a paint receipt or contractor invoice.

Anti-fouling systems to be prohibited or controlled will be listed in an annex (Annex I) to the convention, which will be updated as and when necessary.

As recommended by the 21st session of the IMO Assembly, the conference agreed to an effective implementation date of 1 January 2003 [1] for a ban on the application of organotin-based systems.

In November 1999, IMO adopted an Assembly resolution that called on the MEPC to develop an instrument, legally binding throughout the world, to address the harmful effects of anti-fouling systems used on ships. The resolution called for a global prohibition on the application of organotin compounds, which act as biocides in anti-fouling systems on ships by 1 January 2003, and a complete prohibition by 1 January 2008.

The new convention will enter into force 12 months after 25 States representing 25% of the world's merchant shipping tonnage have ratified it.

Annex I attached to the convention and adopted by the conference states that by an effective date of 1 January 2003, all ships shall not apply or re-apply organotins compounds which act as biocides in anti-fouling systems.

By 1 January 2008 (effective date), ships either:

(1) Shall not bear such compounds on their hulls or external parts or surfaces; or
(2) Shall bear a coating that forms a barrier to such compounds leaching from the underlying non-compliant anti-fouling systems.

This applies to all ships (including fixed and floating platforms, floating storage units (FSUs), and Floating Production Storage and Offtake units (FPSOs).

The convention includes a clause in Article 12 which states that a ship shall be entitled to compensation if it is unduly detained or delayed while undergoing inspection for possible violations of the convention.

The convention provides for the establishment of a "technical group", to include people with relevant expertise, to review proposals for other substances used in anti-fouling systems to be prohibited or restricted. Article 6 on Process for Proposing Amendments to controls on anti-fouling systems sets out how the evaluation of an anti-fouling system should be carried out.

times). A key question is who is liable for this cost: the public, port and harbor authorities, shipyards and dry-docks or ship owners and operators and/or chemical and paint manufacturers.

[1] It was recently noted at IMO that until such time as the Convention enters into force, States cannot apply the retroactive requirements of the Convention to foreign ships calling at a State's ports prior to its entry into force.

Regulatory questions/issues related to the treaty

Some open ended regulatory questions—concerns/issues with the convention/treaty have been identified that will need to be worked out in the future as the Treaty is implemented:

Removal versus over-coating of the TBT?

- Total removal
- Over-coating alone
- Over-coating with sealer coat
- Port state inspections
- Testing hull coatings and MARPOL standard of "Clear Grounds"

Over coating or sealers?

- Can you identify and age the TBT on a hull?
- Can you estimate the TBT release rates of aged TBT?
- How accurate are release rate protocols?
- Can you over coat or seal undercoats of TBT on a vessel?
- Does TBT leach through?

Enforcement?

- Balance of port—state mechanisms and flag-state certification?

- Will effective enforcement require removal of earlier TBT-based coatings?
- Policing?
- Inspection?
- Monitoring?
- Costs?

Treaty enforcement needs?
- A rapid—inexpensive analysis method for TBT?
- Inspection, detection analytical procedures/technologies?
- Underwater Hull inspection and policing mechanisms?
- Hull free TBT certification process?

Liabilities related to the treaty?
- Inspection, detection, policing and certification?
- Treatment of shipyard wastes?
- Introduction of invasive species?
- Contaminated bottom sediments?
- Acceptance in the marketplace of "Comparable" alternatives?
- "Catch 22" from available alternatives?

Liability for the costs for dredging, treatment and disposal of TBT contaminated sediments?
- Port and Harbor authorities?
- Shipyards?
- Ship Owners?
- Chemical and paint companies?

In the US, only the state of Virginia has discharge regulations for TBT in washdown and hydroblast waters from shipyards and drydocks. Without proven technologies, the State of Virginia initially set the regulatory discharge limit at 50 parts per trillion (ng/L) TBT for shipyards and gave them a 5 years compliance period that ended in September 1999. Full-scale efforts all failed to consistently achieve this level. Consequently in 2003, this regulation was modified by the State to 720 ng/L per event with a total of 3 kg of TBT discharged per year per shipyard in the state. When a ship is first placed in a drydock, the vessel is washed down with freshwater to remove salt and prevent corrosion. This washwater is discharged directly to local rivers, estuaries or bays. The hydroblasting can break up the removed paint into paint chips into 10 μm size particles, which can be widely distributed in waterways.

Over the past few years, this hydroblasting has become the preferred method to remove anti-fouling marine coatings (paints) from a ship's hull because of the human health risks from breathing sand blasted materials. Without national regulations on discharge requirements, this practice will continue and significantly increase between 2003 and 2008 as a result of the treaty. Contaminated washdown (salt and slime removal) wastewaters from a large ship can exceed 100,000 gallons hydroblasting (for total paint removal) wastewater from the same ship can exceed an additional 400,000 gallons (Fox et al., 1999) in 36 h period. Rainfall runoff alone in a drydock can reach 20,000 gallons (Akan et al., 1999; Kura and Tadimalla, 1999a,b).

3. Dealing with TBT contaminated shipyard wastewaters

The Environment Protection Agency (EPA)—has funded several projects to develop and test wastewater treatment technologies to the Center for Applied Ship Repair and Maintenance (CASRM) and Old Dominion University in Virginia. These studies have found that washdown (salt removal) and hydroblast (paint removal) wastewaters in shipyards can contain up to 6 million parts per trillion TBT (Fox et al., 1999; Johnson, 1999). In Virginia, this wastewater is treated to remove TBT from shipyard discharges. Researchers at Old Dominion University have demonstrated that off-the-shelf waste treatment technologies were not satisfactory for the treatment and removal of TBT in these wastewaters (Schafran et al., 2001). In addition, US, Australian, UK and Swiss studies to remove TBT and other metals from wastewaters have found that advanced technologies not commonly utilized in normal sanitary treatment plants are required to remove TBT (Fletcher and Lewis, 1999; Ashcroft and Abel, 1999; Abel and Abbott, 2001).

Studies conducted by EPA, US Navy, UK DOE and the Consortium of Organotin Manufacturers Association (ORTEPA) have recorded declining levels of TBT worldwide, yet documented 'hot spots' of TBT in bottom sediments in the proximity of shipyards, drydocks, marina's, ports and harbors (Champ and Seligman, 1996; Champ, 2000).

An example of how contamination can increase the costs for disposal of dredged material is seen in the two alternatives available to the Port of NY/NJ. The Mud Dumpsite, located 3 miles offshore, has been operational for many decades and has been the traditional disposal area that can accept clean dredged materials. Contaminated "spoils" have to be disposed of at an upland hazardous waste disposal facility. From 1977 to 1991, 90% of all NY/NJ dredge spoils were tested and classified, as clean spoils and only 1–2% were contaminated spoils. However, in 1991 the US EPA required bioassay testing. This increased the volume of contaminated spoils.

For contaminated dredged material, the currently available alternative is upland disposal at a hazardous materials storage facility and none are available in the near vicinity. Howland Hook Terminal in Staten Island shipped 150,000 yd^3 of sediment via barge and rail to Utah at a cost of US$17 million or over $110/$yd^3$.

The Diplomatic Conference adopted four resolutions:

Resolution 1. Early and effective application of the convention—The resolution invites Member States of the Organization to do its utmost to prepare for implementing the convention as a matter of urgency. It also urges the relevant industries to refrain from marketing, sale and application of the substances controlled by the convention.

Resolution 2. Future work of the organization pertaining to the convention—The resolution invites IMO to develop guidelines for brief sampling of anti-fouling systems; guidelines for inspection of ships; and guidelines for surveys of ships. The guidelines are needed in order to ensure global and uniform application of the articles of the convention, which require sampling, inspection and surveys.

Resolution 3. Approval and test methodologies for anti-fouling systems on ships—This resolution invites States to approve, register or license anti-fouling systems applied in their territories. It also urges States to continue the work, in appropriate international fora, for the harmonization of test methods and performance standards for anti-fouling systems containing biocides.

Resolution 4. Promotion of technical co-operation—The resolution requests IMO Member States, in co-operation with IMO, other interested States, competent international or regional organizations and industry programs, to promote and provide directly, or through IMO, support to States in particular developing States that request technical assistance for:

(a) the assessment of the implications of ratifying, accepting, approving, or acceding to and complying with the convention;
(b) the development of national legislation to give effect to the convention; and
(c) the introduction of other measures, including the training of personnel, for the effective implementation and enforcement of the convention.

It also requests Member States, in co-operation with IMO, other interested States, competent international and regional organization and industry programs, to promote co-operation for scientific and technical research on the effects of anti-fouling systems as well as monitoring these effects.

Traditional fees for dumping dredge materials at the Mud Dumpsite are in the area of \$10/yd^3 (Champ, 1999, 2001c,d).

Therefore, concern was expressed over the need to identify regulatory language within the treaty itself for the "safe" removal, treatment and disposal of TBT from ships, and clarification on the issue of liability of future dredging and disposal of TBT-contaminated port and harbor sediments. Under current regulatory practices for most of the world, TBT in washdown wastewaters can be discharged directly into local waters.

It is quite possible that the "regulated" nations can quickly implement new requirements to correct this situation. This implementation will result in the transfer TBT contamination to the "unregulated" countries, which are least able to deal with it. However, at IMO, there is a concern that unregulated countries may unknowingly accept the environmental and human health risks to gain economic benefits from removing TBT from ship's hulls. Market forces are selective for low-cost labor and weak environmental regulation. Unfortunately, most of these developing countries do not have the funding or environmental expertise available for the monitoring, research and technology development essential to treat and dispose TBT washdown wastewaters safely. These activities would defeat the purpose of the treaty, which is to provide standardized global regulation and ensure that shipowners do not face multiple, fragmented and counter productive national regulations.

It has been estimated that between 70% and 80% of the 28,038 ships in global commerce use TBT. Under current practices, the estimated annual increase in wastes in shipyards and drydocks from the treaty will be: 2.3 million tons of contaminated grit, 18,000 tons of spent paint, 1.8 million paint cans, and 1.1 billion gallons of contaminated washwater (low pressure for salt removal), and if the trend increases of using high pressure hydroblasting to remove spent paint, the volume of wastewater could exceed 5 billion gallons of water needing treatment.

Photograph of the CASRM barge mounted TBT wastewater treatment plant.

4. Impact on ports and harbors

A group of Delegations [Cyprus, Brazil, Denmark, Liberia, Marshall Islands and Vanuatu (formerly New Hebrides)] stressed the need for language in the treaty requiring safe removal, treatment and disposal of TBT from ships, at MEPC 46 [a meeting of the IMO Marine Environmental Protection Committee held in London on 23–27 April 2001]. Subsequently in Plenary at MEPC 46, the delegates then instructed the drafting committee to include a new article to regulate the "application or removal of anti-fouling systems" that are banned, requiring that they be "collected, handled, treated and disposed of in a safe and environmentally sound manner to protect the environment and human health" (documents from discussions at previous MEPC Meetings can be found on line at: http://www.uscg.mil/hq/g-m/mso/mso4/tbt.html). For most of the world, TBT in washdown and shipyard wastewaters can legally be discharged directly into local waters. In some places they are circulated (ineffectively) through a municipal waste treatment plant.

However, before the language of the treaty is ratified, member nations should be aware of additional considerations. Safe methods for removal and treatment of the spent paint (with biocides) must be defined. Where bottom sediments contain TBT's, either from past activities or from paint removal in compliance with the treaty, port authorities would benefit also from defining who is liable for the increased costs of dredging and treating the TBT contaminated dredged material.

A conference was recently held at the Technical University of Denmark in Lyngby, Denmark to bring together researchers on "Environmental Aspects of Handling Heavy Metal and TBT-Polluted Harbor Sediment". International experts indicated that a cost-effective system for remediation of persistent TBT (mostly paint chips) in contaminated bottom sediments might not be available for several years. For more information, see Reed et al. (2001) and Eschenbach et al. (2001).

Without incorporation of Article 5 in the treaty, shipyards complying with national and local discharge regulations could inadvertently release more TBT to ports and harbors in the five-year compliance period than has been released from ships (hulls) in the past 40 years to the same waters. This would be devastating to the marine environment.

Facts/Questions/Issues/Concerns

TBT from shipyards and drydocks:

- Hydroblasters removes paint in less than 10 micron size particles—widely dispersed in discharged waters
- The residence time of TBT in seawater has been found to be < than a month and partitions rapidly to particulate matter and bottom sediments
- Degradation of TBT in sediments is slower with half-life values ranging from years to decades in sediments.
- Paint chips—unknown

Treatment of ship washdown and shipyard wastes:

- To achieve discharge permit levels?
- To treat solid wastes for disposal in landfills?
- Costs?
- Number of ships between 2001–2008?
- Number of available shipyards?

Hull washdown wastewaters:

- First operation in dry-dock
- 24–30 hours continuous work
- 10–15 men with pressure wands
- 40–60 GPM waste water generation
- Up to 150,000 gallons per ship

TBT levels measured in shipyard wastewaters:

- Up to 5,000,000 ng/1 (PPT) in waste water levels, and
- Discharge to local waters

When the treaty enters into force, it will be implemented to remove the TBT from ships to protect the marine environment. The regulatory gap between removal and disposal may contaminate port and harbor bottom sediments. Consequently, ports and harbors (who had nothing to do with the treaty) could be at risk for the liability of treatment and disposal of these (now) highly toxic (TBT contaminated) bottom sediments in special landfills. The key question then becomes who is liable for the costs of removing and disposing these TBT contaminated dredged materials: shipowners, shipyards, or port and harbor authorities?

Questions/Issues/Concerns

Identification and minimization of liability?

- Port and Harbor detection of TBT dredging problem?
- Sediment monitoring
- Distribution and abundance of TBT in port and harbor bottom sediments
- Identify waste treatment options
- Solutions have to be tailor made for local requirements, conditions and specifics

Port and Harbor—Data and information requirements?

- TBT expertise
- Local assessment and monitoring expertise
- Dredging and TBT waste treatment systems expertise

Regulation of "Contaminants" in dredged materials?

- Under Annex I of the London Dumping Convention, *Contaminants in dredged materials can be ocean*

dumped if they are not greater than trace background levels, and not be persistent, toxic or bioaccumulate. Regarding TBT, it is a man made compound that does not occur in the marine environment, it is considered the most toxic material ever added to the marine environment (Goldberg, 1986), and filter feeding bivalves readily accumulate TBT. Bioaccumulation factors (BAF) reported in the literature are as high as 50,000 (Laughlin, 1996). For more discussion on bioaccumulation of TBT from bottom sediments, see Champ (2000)

5. Summary

One of the purposes of focus papers is to identify a concern before it becomes an issue. In the time that the first draft of this paper was written till now, TBT paint residues in dredged materials have lead to the closure of floating dock and dry cock at the Vuosaari shipyard at the Port of Helsinki in Finland. In addition, Wade et al. of TAMU has submitted a manuscript to *Environmental Pollution* entitled: ''TBT in Environmental Samples from the former Derecktor Shipyard, Coddington Cove, Newport, Rhode Island, USA'', where they have found TBT levels in bottom sediment are likely to be having an adverse effect on biota. These are early red flags, shipyards need to become proactive on this problem and not wait till after the last TBT has been removed from ships to realize that it is now downstream of them and they have released more TBT to the coastal environment than ships have over the last 40 years.

References

Abel, D., Abbott, A., 2001. Treatment processes for TBT-contaminated waters and sediments. In: Proceedings of Oceanology International 2001 Conference, vol. 1. Miami, FL, pp. 14–21.

Akan, O., Schafran, G.C., Pommerenk, P., Harrell, L.J., 1999. Simulation of stormwater runnoff from marine drydocks. In: Proceedings of Oceans '99, Seattle, Washington, vol. 4. The Marine Technology Society, Washington, DC, pp. 1–16.

Ashcroft, P., Abel, D., 1999. Process water treatment for the removal of TBT in ship washdown wastewaters. In: Proceedings of Oceans '99, Seattle, Washington, vol. 4. The Marine Technology Society, Washington, DC, pp. 73–75.

Champ, M.A., 1999. An overview of the science and regulation of TBT and the potential for future liability for contaminated harbor sediments. In: Proceedings of Oceans '99, Seattle, Washington, vol. 4. The Marine Technology Society, Washington, DC, pp. 137–152.

Champ, M.A., 2000. A review of organotin regulatory strategies: Pending actions, related costs and benefits. Science and the Total Environment 258 (1), 21–71.

Champ, M.A., 2001a. New IMO convention to control harmful antifouling systems on ships. Sea Technology 42 (11), 48–51.

Champ, M.A. (Chairman and Editor), 2001b. Proceedings of the international symposium on pollution prevention from ships and shipyards. In: Oceanology International 2001 Conference, vol. 1. Miami, FL. Office of Naval Research, 223p. Proceedings available from ATRP Corp.

Champ, M.A., 2001c. Potential economic and environmental consequences of the convention to ban harmful marine antifouling systems. In: Proceedings of the Oceanology International 2001 Conference, vol. 1. Miami, FL, pp. 198–200.

Champ, M.A., 2001d. The IMO convention to ban TBT and its subsequent impact on port and harbor infrastructure and operations. Maritime association port of New York and New Jersey. In: Dredging Remediation and Environmentally Sustainable Harbors Conference. 3–4 April 2001. Mashantucket, CT, p. 23.

Champ, M.A., Fox, T.J., Mearns, A.J. (Co-Chairmen and Editors), 1999. Treatment of regulated discharges from shipyards and drydocks. In: Proceedings of Oceans '99 Conference, Seattle, Washington, vol. 4. 13–16 September 1999. The Marine Technology Society, Washington, DC, Office of Naval Research. ISBN No. 0-933957-24-6. 223p. Proceedings available from ATRP Corp.

Champ, M.A., Seligman, P.F. (Eds.), 1996. Organotin: Environmental Fate and Effects. Chapman & Hall Publishers, UK. 29 Chapters, 664p.

Eschenbach, A., Höhne, J., Söö, Z., Luther, G., 2001. The steam stripping process: a remediation technique for TBT- and PAH-contaminated dredged sediments and soils. In: Proceedings of 2001 International Containment and Remediation Technology Conference and Exhibition. 10–13 June 2001, Orlando, FL, p. 3.

Fletcher, L.E., Lewis, J.A., 1999. Regulation of shipyard discharges in Australia and the potential of UV oxidation for TBT degradation in washdown wastewater. In: Proceedings of Oceans '99, Seattle, Washington, vol. 1. The Marine Technology Society, Washington, DC, p. 27–36.

Fox, T.J., Beacham, T., Schafran, G.C., Champ, M.A., 1999. Advanced technologies for removing TBT from ship washdown and drydock runoff wastewaters. Proceedings of Oceans '99, Seattle, Washington, vol. 4. The Marine Technology Society, Washington, DC, pp. 63–72.

Johnson, D., 1999. Discharge of tributyltin in state of virginia waters. In: Proceedings of Oceans '99, Seattle, Washington, vol. 4. The Marine Technology Society, Washington, DC, pp. 41–50.

Kura, B., Tadimalla, R., 1999a. Characterization of shipyard wastewater streams. In: Proceedings of Oceans '99, Seattle, Washington, vol. 4. The Marine Technology Society, Washington, DC, pp. 17–26.

Kura, B., Tadimalla, R., 1999b. Minimization and treatment of shipyard wastewater. In: Proceedings of Oceans '99, Seattle, Washington, vol. 4. The Marine Technology Society, Washington, DC, pp. 77–90.

Reed, J., Waldock, M., Jones, B., Blake, S., Roberts, P., Jones, G., Elverson, C., Hall, S., 2001. Remediation techniaues applied to reduce the environmental impact of paint-derived TBT in dredged material—a pilot study. In: Proceedings of the Oceanology International 2001 Conference, vol. 1. Miami, FL, pp. 93–96.

Schafran, G.C., Tekleab, T.M., Prasad, R., Fox, T.J., Champ, M.A., Johnson, D., 2001. Removal of TBT from shipyard waters: laboratory unit process evaluations and one-year of full-scale shipyard-based treatment. In: Proceedings of the Oceanology International Conference, vol. 1. Miami, FL, pp. 1–13.